Storage and Retrieval Unit and Method for Longitudinal Positioning on a Shelf in a Commissioning System

The present invention pertains to a storage and retrieval unit according to the preamble of claim 1 as well as to a method for the longitudinal positioning of the storage and retrieval unit at a site of operation of a shelf on the shelf front or the shelf rear, wherein a height-adjustable goods receiver is provided at a vertical mast.

An above-mentioned, prior-art storage and retrieval unit is frequently guided in rails on the bottom side within a commissioning system and is displaceable in parallel or longitudinally on the shelf front or the shelf rear by means of an electric motor and can be positioned at a selected site of operation of the shelf. The storage and retrieval unit usually has a traveling tower or a vertical mast at the level of the shelf to be operated, usually in a warehouse, wherein the shelf may extend over several levels or stories. Because of the relatively great height of the traveling tower, the storage and retrieval unit is comparatively unstable due to the bottom-side drive. Additional stability is achieved due to a complicated construction of the traveling tower and an additional longitudinal guiding of the storage and retrieval unit in the area of the ceiling of the warehouse or in the area of the top side of the shelf. Besides the bulky design, it is disadvantageous that the storage and retrieval unit can be displaced only relatively slowly and can be positioned at a desired site of operation of the shelf in a relatively time-consuming manner only. If the tall traveling tower is

being moved or cycled too fast, there is a risk that the traveling tower will tilt or jam in the area of the ceiling or the top side of the shelf. However, the traveling tower is at least exposed to great bending moments, and the upper longitudinal guide is subject to heavy load and to great wear.

To eliminate the above-mentioned drawback, a second, top-side longitudinal drive, which is operated synchronously with the bottom-side drive, is known in a storage and retrieval unit, in addition to the bottom-side drive according to the state of the art, for example, according to DE 202 05 633.3. It is advantageous here that faster displacement and positioning of a storage and retrieval unit in front of or behind a shelf or within a complex commissioning system is possible as a result and the traveling tower of the storage and retrieval unit can have a relatively slender design, because the dynamic bending forces are diverted by means of the second, top-side longitudinal drive.

However, it was found that precisely in case of great heights of the vertical mast or traveling tower over a plurality of levels of a shelf in a tall, usually multi-story building, the long mast itself is subject to strong transverse acceleration forces during faster travel, especially because the vertical mast carries the load to be commissioned, and faster displacement and positioning of the storage and retrieval unit is possible as a result only conditionally. Moreover, the storage and retrieval unit must be designed for an emergency stop and have a correspondingly stable design. Consequently, the forces occurring at the long mast are always transmitted via long levers. In particular, the bending moments occurring at the mast in emergency stop situations are very high, and they cause problems above all at the end position buffers. Even in case of an additional drive at the upper mast guide, strong forces will consequently sometimes develop at the support points of the upper and

lower chassis, especially because, due to the additional drive, new forces may be introduced into the system, which is no longer determined statically.

The object of the present invention is to create a storage and retrieval unit of the type mentioned in the introduction, which makes possible fast and stable, reliable longitudinal positioning at a site of operation of the shelf with astonishingly simple means even in case of a comparatively great mast height.

The object of the present invention is, furthermore, to create a simplified working method for the longitudinal positioning of the above-mentioned storage and retrieval unit.

The basic object of the present invention is accomplished by a storage and retrieval unit of the type described in claim 1, advantageously perfected by the features of claims 2 through 15, as well as by a method of the type described in claims 16 and 17.

The essence of the present invention is that in a storage and retrieval unit of the type in question, the mast is designed as an articulated mast and has at least one joint, which makes possible the deflection of the articulated mast in the direction of longitudinal displacement. In the area of the deflectable mast end, the articulated mast is equipped here for stabilization with a guide/readjusting device, which returns the articulated mast into the normal position in a guided manner in case of the guided deflection of the articulated mast from the vertical normal position. The guide of the articulated mast is designed such that even though the deflectable end of the articulated mast can pivot unhindered in the direction of longitudinal displacement in an arc-shaped pattern, on the one

hand, it is guided restrictedly at least in the transverse direction, and, in particular, it is also guided restrictedly along the "arc" in the longitudinal direction, on the other hand.

The joint is preferably located in the area of the longitudinal drive, which is arranged especially in the area of the upper or lower mast end. In a special variant, the articulated mast is either suspended on an upper chassis or is supported on a lower chassis.

In a special embodiment, the guide/readjusting device has another longitudinal drive of the type of the first longitudinal drive, and both longitudinal drives are preferably operated synchronously.

The two synchronously driven longitudinal drives are preferably controlled such that the tilting mast continues to be arranged vertically during the normal operation of longitudinal displacement of the storage and retrieval unit, while guided deflection of the tilting mast takes place in case of an emergency stop of the storage and retrieval unit.

However, the two longitudinal drives may also be controlled such that the storage and retrieval unit is displaced linearly in the direction of the shelf from a resting starting position of the shelf, accelerated to a selected site of operation of the shelf and decelerated before the site of operation is reached, such that the articulated mast is deflected in a guided manner during at least part of the accelerated and/or decelerated motion and is again adjusted in a guided manner into the aligned vertical normal position at least during stoppage of the storage and retrieval unit.

Great mast heights of a storage and retrieval unit can be advantageously embodied by the present

invention, and the storage and retrieval unit can be displaced equally fast and reliably, without break in the normal operation, and emergency operation or an emergency stop is also possible without rupture of individual parts and without excessive load on the support points of the one or more chassis. If longitudinal drives are arranged at the top and at the bottom, the traveling system is likewise operated in a statically determined manner. Thus, the traveling system forgives minor asynchronisms in the two longitudinal drives. End position buffers in the shelf can be made as relatively short buffers, e.g., relatively short buffer paths are provided. A special advantage of the present invention is that because of the relatively low stress on the bearing points of the one or more chassis, the chassis can be designed as compact, especially short and light-weight chassis, without the chassis being able to tilt, and a longer operating area can also be obtained in the bay aisle.

Other advantageous features of the present invention appear from the following description, in which preferred exemplary embodiments of the present invention will be explained in greater detail on the basis of the drawings; in the drawings,

Figure 1 shows a schematic perspective cut-away view of storage and retrieval units according to the present invention arranged in a bay aisle of a double shelf of a commissioning system,

Figure 2 shows a first embodiment variant of the storage and retrieval unit according to Figure 1,

Figure 3 shows a second embodiment variant of the storage and retrieval unit according to

Figure 1,

Figure 4 shows a side view of the storage and retrieval unit according to Figure 2 in its two deflected positions,

Figure 5 shows a side view of the storage and retrieval unit according to Figure 4 in its vertical normal position,

Figure 6 shows a front view of the storage and retrieval unit according to Figure 5,

Figure 7 shows a perspective view of upper and lower details of the storage and retrieval unit according to Figures 2 through 6,

Figures 8 and 9 show force diagrams of a storage and retrieval unit according to Figure 2 (left) compared to the state of the art (right), and

Figure 10 to 13 show the second embodiment variant of the storage and retrieval unit according to Figure 3 in views similar to those of the first embodiment variant in Figures 4 through 7.

According to the drawings, a commissioning system, which is of no particular interest here, comprises a double shelf according to Figure 1, comprising two shelves 3 with a storage and retrieval unit 1 arranged in the bay aisle, either in the embodiment variant according to Figure 2 or

in the embodiment variant according to Figure 3.

According to Figure 1, the storage and retrieval units 1 are guided on the top side and on the bottom side in rails 10, which are integrated parts of the shelves 3, i.e., components of the shelves.

The storage and retrieval units 3 can be displaced horizontally in the longitudinal direction L of the shelves 3 in the bay aisle in levels I, II, III of the shelves 3, which levels are arranged one on top of another, and operate shelf fronts facing them.

The storage and retrieval units 3 can be displaced vertically by means of an elevator 20 from one shelf level into another selected shelf level and used in this shelf level in the bay aisle by horizontal displacement.

The elevator 20 according to Figure 1 is located at a longitudinal end of the shelves 3. A material or goods elevator 21, which transports goods to be commissioned vertically into the selected shelf level before the storage and retrieval unit 3 [sic - Tr.Ed.] located there grasps the goods for introduction into a shelf or releases them there after retrieving them from the shelf, is located at the other longitudinal end of the shelves. The goods 2 may also be displaced vertically in the elevator 20 together with the storage and retrieval unit 3 [sic - Tr.Ed.].

A storage and retrieval unit 1 according to Figure 1 has a vertical mast 4 and has, on the one hand, a longitudinal drive 5 connected to the mast at the top and, on the other hand, another longitudinal drive 6 at the bottom according to Figure 2 for longitudinal displacement and longitudinal

positioning of the storage and retrieval unit at a site of operation of the shelf on the shelf front and on the shelf rear, a height-adjustable goods receiver 7 being provided at the vertical mast.

In particular, the mast is designed as an articulated mast 4 with a joint 8, which makes possible the guided deflection A of the articulated mast in the direction of longitudinal displacement L, as this is shown in Figures [sic - Tr.Ed.] 4.

The joint 8 is located at the upper end of the mast in the area of the upper longitudinal drive 5.

In particular, the articulated mast 4 is suspended on an upper chassis 12 according to Figure 7 in a pendular arrangement. At the other, lower deflectable mast end, the articulated mast 4 has a guide/readjusting device 9 for stabilization, which returns the articulated mast 4 into the normal position in a guided manner in case of a guided deflection A of the articulated mast 4 from the vertical normal position N. The guiding of the articulated mast is designed such that even though the deflectable end of the articulated mast can pivot unhindered in the direction of longitudinal displacement in an arc-shaped pattern, on the one hand, it is guided restrictedly at least in the transverse direction, especially it is also guided restrictedly along the "arc" in the longitudinal direction, on the other hand.

The guide/readjusting device 9 is connected to the lower other longitudinal drive 6 in an articulated manner.

The upper and lower longitudinal drives 5, 6 are essentially of identical design. Both longitudinal

drives 5, 6 are driven synchronously such that the articulated mast 4 is arranged vertically according to Figure 5 during the normal operation of the longitudinal displacement L of the storage and retrieval unit 1, and that guided deflection A of the articulated mast 4 takes place during an emergency stop of the storage and retrieval unit according to Figure 4, depending on the direction of action of the decelerating force.

The guide/readjusting device 9 has articulated rods, especially an articulated oscillating crank 9', which is pivotable about a horizontal axis, the lower end of the mast being connected to the oscillating crank 9' in an articulated manner.

A bent guide, especially a sliding guide with lateral sliding blocks at the deflectable end of the articulated mast, which [said guide/readjusting device] makes possible the exact bent guiding of the deflectable end of the articulated mast during unhindered deflection of the articulated mast along the arc and clearance-free guiding in the transverse direction, may be provided, in particular, at the deflectable mast end.

The guide/readjusting device 9 may also comprise elastic readjusting means.

In a special embodiment, the upper and lower chassis 12, 13 have four horizontal axes with end-side rollers 14, which are guided nontiltingly in the rails 10, wherein two axes each are arranged one on top of another and the two axis pairs are located at horizontally spaced locations from one another, preferably at a distance d corresponding to 2 to 3 times the diameter of the rollers 14, as this is shown in Figure 5.

The respective chassis 12 and 13 have an electric drive 18 of their own with a friction wheel 17 as the driving wheel, which meshes with one of the rails 10 in a friction-rolling driving manner.

The articulated mast 4, especially the joint 8, may also have a blocking device (not shown), which prevents deflection A of the articulated mast up to a mast load limit value and permits the deflection A of the articulated mast 4 when the mast load limit value is exceeded.

The mast load limit value may optionally be set. The mast load limit value may be a lateral force limit value of the articulated mast 4 or an acceleration/deceleration limit value of the longitudinally displaceable storage and retrieval unit.

An above-mentioned storage and retrieval unit 1 according to Figures 2 and 4 through 7 can be operated not only in such a way that the articulated mast 4 continues to be arranged vertically according to Figure 5 during the normal operation of a longitudinal displacement of the storage and retrieval unit 1, while guided deflection A of the articulated mast 4 takes place according to Figure 4 in case of an emergency stop of the storage and retrieval unit, but also such that the storage and retrieval unit 1 is displaced linearly in the longitudinal direction L of the shelf, in case of corresponding control, from a resting starting position of the shelf 3, accelerated to a selected site of operation of the shelf and decelerated before the site of operation is reached, such that the articulated mast 4 is deflected in a guided manner during at least part of the accelerated and/or decelerated motion according to Figure 4 and is again readjusted in a guided manner into the aligned vertical normal position N according to Figure 5 at least during stoppage of the storage and retrieval unit.

Figure 8 schematically shows the above-mentioned storage and retrieval unit 1 according to the present invention with the articulated mast 4 suspended at the upper chassis 12 in the joint with respect to the action of forces, while Figure 9 shows the forces in the state of the art with rigid mast and lower chassis 13.

According to Figure 9, the forces are transmitted at the vehicle [sic - possible typo for word meaning "chassis" - Tr.Ed.] via large levers according to the state of the art. High bending moments, which cause problems especially in emergency stop situations at the end position buffers of the shelf 3 and the rails 10, occur at the mast. The consequence of this is long buffer paths in order to keep the deceleration/acceleration low. Strong forces will sometimes develop at the support points of the chassis and the rollers 14 even if an additional drive is used at the upper mast guide, because new forces are introduced due to the additional drive. The system is no longer determined statically.

According to Figure 8, the mast is suspended, by contrast, in an articulated manner according to the present invention at the upper guide carriage as an articulated mast 4 via a joint 8. The lower carriage is used for stabilization only, i.e., for the vertical alignment of the mast. This pendular arrangement with the formation of an oscillating crank cannot tilt in case of error. The system also cannot self-destruct in case of error, either, e.g., in case of rupture of the belt in a toothed belt drive or in case of failure of the needed frictional engagement in a friction wheel drive. The maximum bending moments in the articulated mast 4 are low. The forces are introduced at the upper guide carriage at the hinge point of the mast. The energy of impact at the end positions is divided between the two guide carriages. It is also possible to embody shorter buffer paths due to the lower

moments to be expected in case of an impact.

While the articulated mast 4 is suspended in an articulated manner at the top at the upper chassis 12 in case of an upper joint 8 at the upper end of the mast in the first embodiment variant described above, the arrangement is shown inverted concerning the articulated mast and is stabilized at the lower chassis by means of articulated rods with an oscillating crank 9', the arrangement is shown inverted concerning the articulated mast, the hinge point and the chassis according to Figures 3 and 10, i.e., the articulated mast 4 is supported at a lower joint 8 at the lower end of the mast at the lower chassis 13 in an articulated manner, and the deflectable mast end is provided at the upper chassis 12 with the oscillating crank 9' and the guide/readjusting device 9, etc. Corresponding components of this second variant otherwise have a design identical or similar to that in the first variant.